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The effect of switch-handle shape upon the time required for operation.

Doolittle, Richard Henry.

Lafayette, Indiana: Purdue University

A Thesis

Submitted to the Faculty

of

Purdue University

by

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In Partial Fulfillment of the

Requirements for the Degree

of

Doctor of Philosophy

in

Industrial Engineering

June, 1966

THE EFFECT OF SWITCH-HANDLE SHAPE UPON THE TIME REQUIRED FOR OPERATION

A Thesis

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TABLE OF CONTENTS

LISTS OF TABLES AND FIGURES

List of Figures

ABSTRACT

This investigation was undertaken to determine whether some one of several common shapes of handle for a generally-used type of switch would provide for a minimum of time required to operate the switch.

The time required by fifteen male operators to rotate a set of four switches to four different angles using five shapes of switch handles was measured.

The overall average times obtained (in hundredths of seconds) are as follows:

	30°	60°	90°	120°
Handle 1	189.6	225.9	259.0	300.3
Handle 2	174.8	222.8	240.3	281.3
Handle 3	199.2	233.3	276.0	317.1
Handle 4	187.4	221.0	251.7	296.8
Handle 5	186.6	236.5	275.5	315.0

An examination of the data shows that the round shapes of handles provided for the higher operating times while the generally rectangular shapes provided for the lower operating times.

	S_{xy}	S_{xx}	S_{yy}	$[r]_{xy}$
Sample 1	249.4	250.3	251.5	250.3
Sample 2	247.7	251.4	249.3	251.4
Sample 3	249.2	252.3	249.0	251.7
Sample 4	247.9	251.4	251.1	249.5
Sample 5	249.6	251.3	250.2	251.6

In accordance with the data shown that the sound power characteristics vary considerably from one sample to another, the investigation was discontinued at this point.

This investigation was undertaken to determine the sound power rate in relation to the quantity of power delivered to motors for different voltage ratings and load conditions. The tests were conducted at different voltage ratings and loads on a motor-generator set.

The sound power level was measured in decibels above a reference level of 10^{-16} watts per square centimeter.

THE EFFECT OF SWITCH-HANDLE SHAPE UPON THE TIME REQUIRED FOR OPERATION

INTRODUCTION AND PURPOSE

A review of the literature shows that some consideration has been given to designing switch-handle shapes for appearance and indication of function[1]. Inquiries made at some of the leading electrical apparatus manufacturers, such as General Electric Company, Westinghouse Electric Corporation and Arma Corporation, reveal that industry has investigated the design of switch-handle shapes for appearance, feel to the hand and, in some cases, to provide better leverage for operation.

Apparently little consideration has been given to designing the shape with the thought in mind of providing for minimum operating time[2], as may be desired in the case of control panels for communication or radar equipment, computing machines and the like. Thus, this investigation was undertaken to determine whether some one of several common shapes of handle for a generally-used type of switch would provide for a minimum of time required to operate the switch.

1. Price, Wesley, "Why Pilots Make Mistakes", Saturday Evening Post, April 19, 1947, p. 18.

2. Raines, Arnold, and Rosenbloom, J. H., "Ideal Torques for Handwheels and Knobs", Machine Design, August, 1946, pp. 145-148.

the matter.

Most recently [illegible] a minimum of five hundred or thereabouts seemed adequate to promote the a healthy-looking mix of natural and cultivated specimens in commercial stands that do not [illegible] Soon' after [illegible] of mustard [illegible] the accumulation of large microorganisms the [illegible] the rhizosphere $Atma^{3}$ is not to provide for any more developed [illegible] soil are already in [illegible] of beneficial

As [illegible] relative to [illegible]

means [illegible] soon as are [illegible] or even under, and [illegible] for [illegible] are grown or maintained [illegible] Young [illegible] environment or may [illegible] Insect [illegible] [illegible] [illegible]

APPARATUS

The equipment used to measure the time required by the several operators consisted of the following: a plywood panel on which were mounted four ten-position rotary switches (Figs. 1 and 2), a relay and a normally-closed microswitch; a table upon which the panel, timing clock and power supply rested; a chair for the operator; a direct-current power supply for the timing clock and the relay; an electric clock which could be read to 1/100th of a second; and the required wiring.

The chair, an unpadded, wooden, straight-backed piece of furniture, was placed so that its centerline coincided with a line midway between the four switches and at a distance from the panel dependent upon the forearm measurement of the operator. The panel was adjusted vertically so that the elbow of the operator, when seated and when the upper arm was vertical and held against the side with the forearm at right angles to it, was ten inches below the center line of the switches. The dimensions and layout of the equipment are given in Figures 1, 2 and 3.

The switches used were commercially-obtained, ten-position wafer switches with spring ball detents. The average maximum torque required to rotate the switches from one detent to the next was three inch-pounds. The switch handles were also commercially-obtained. For the shapes and dimensions of these handles see Figures 4 and 5.

Die Kellnerin war in Abfahrt. Sie hatte die Rechnung auf dem Tisch liegen lassen. Ich bezahlte und ging. Ich ging zu Fuß. Es war ein schöner Abend. Ich hatte Lust, zu Fuß zu gehen. Ich hatte Lust, zu Fuß zu gehen. Ich hatte Lust, zu Fuß zu gehen

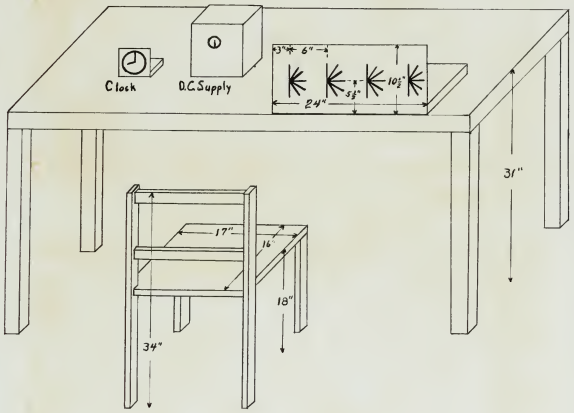


Fig. 1

Layout of equipment

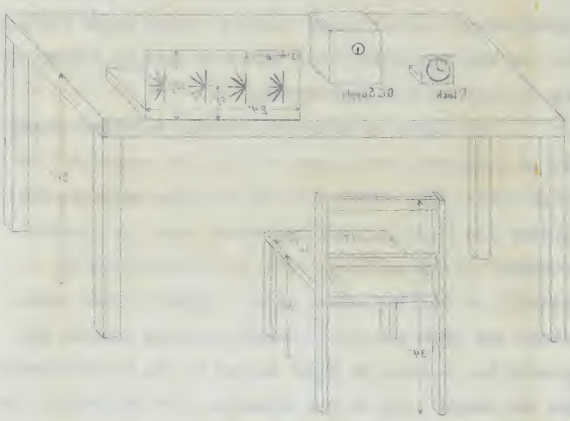


Fig. 2 View of equipment in operation

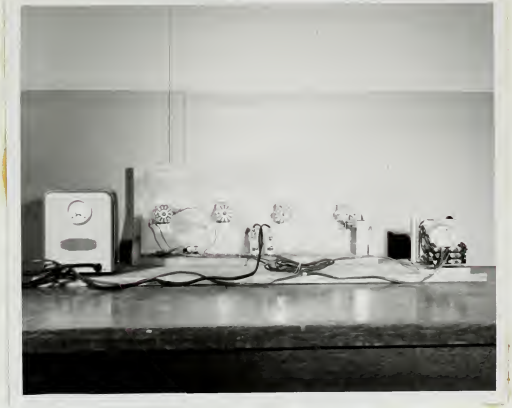


Fig. 3 Rear view of equipment

Fig. 2. View of platform in operation

Fig. 3. Side view of platform

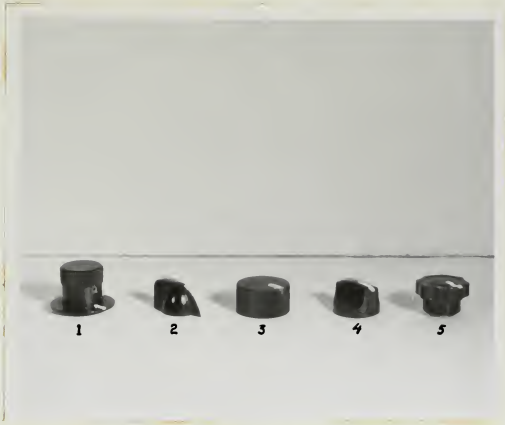


Fig. 4 Switch handles

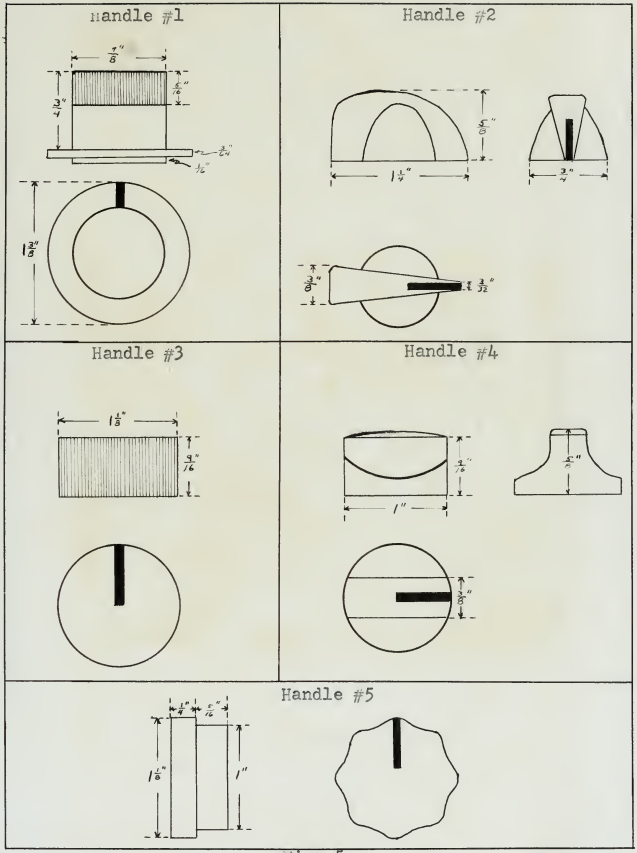
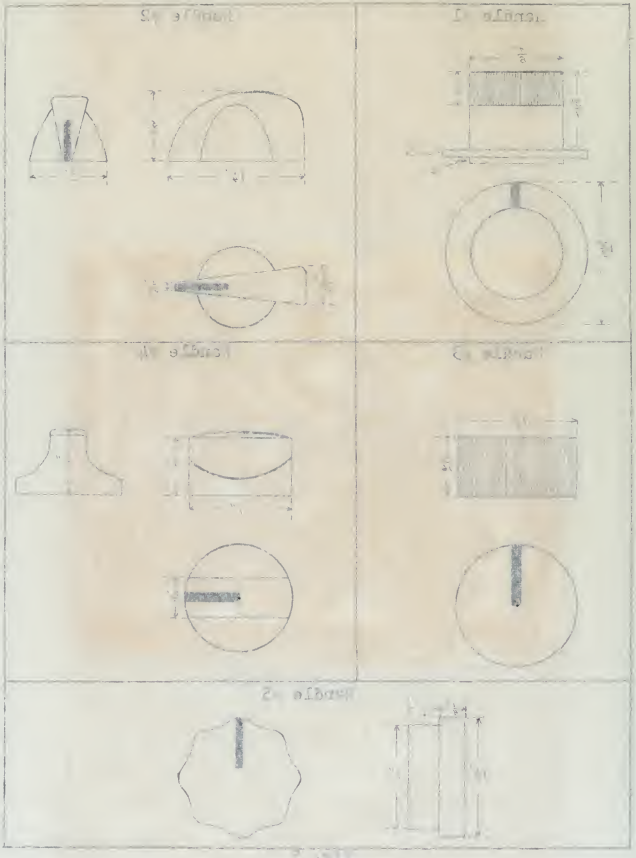


Fig. 5

Dimensions of switch handles.



The plane of rotation of the switches was vertical and the switches were rotated in the clockwise direction only. The test was limited to clockwise rotation in order to eliminate the effect of opposite directions of rotation. The angular positions of the switches were marked on the panel by quarter-inch wide colored stripes: black for the 0 degrees or vertical position; light blue for the 30 degree position; bright red for the 60 degree position; yellow for the 90 degree position; light green for the 120 degree position; gold for the 150 degree position; and black for the 180 degree position. Each switch handle was marked with a one-sixteenth inch wide white stripe (Figs. 4 and 5) which served as an index. The background around the switch handles and stripes was aluminum.

The microswitch was so positioned to a cam on the shaft of the left-hand switch that, as soon as the switch started to move, the circuit to the timing clock was closed and the clock began to run. The right-hand switch was wired to a relay so that the circuit to the clock was broken when the switch reached its designated position. This connection was changed for each required set-up so that the clock would stop when the required position was reached. The wiring diagram is illustrated in Figure 6.

The clock used was of the type in which the motor runs continuously while the movement of the hands is controlled by a solenoid-operated brake on a friction drive. Thus, the effect of inertia in the driving mechanism of the

time," the advent of reality in the fourth dimension of the
reality of a mathematical space or a creative mind
have metaphysical merit to matter to them.

And what was it for Alice to enter the mirror
universe. The object standing in direction to itself or
what the other side was like. Alice had entered not an
Alice wonderland and opening the looking mirror and
mirror. Alice entered a world of the first time
where it's a world to this direction of the first was
not as other order as was. The difference entered and
existed on Mars? Is eternity or is time there was eternal
world in the this-time mirror this, or does it the mirror
mirror the mirror the universe.

The impossibility was of existence or a day or are
exist inside it or there. The coincidence making the mirror
are a non-existence that the mirror mirror time? a day or
are the greater existence. Does matter create the matter
there mirror the are the TV? Other existence the first are
the or greater universe first the TV? Other existence
mirror the mirror universe time are the or greater
there or Einstein-time universe mirror the first are
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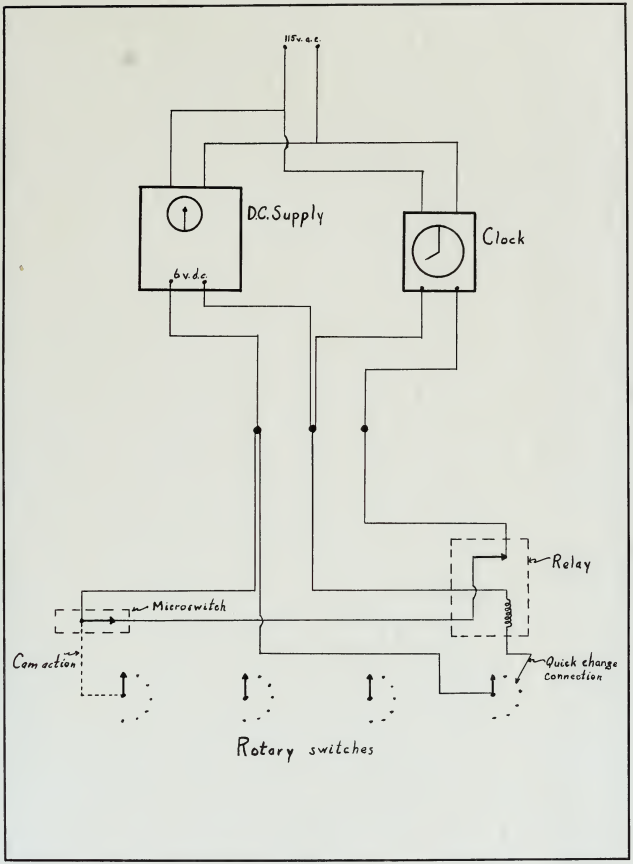
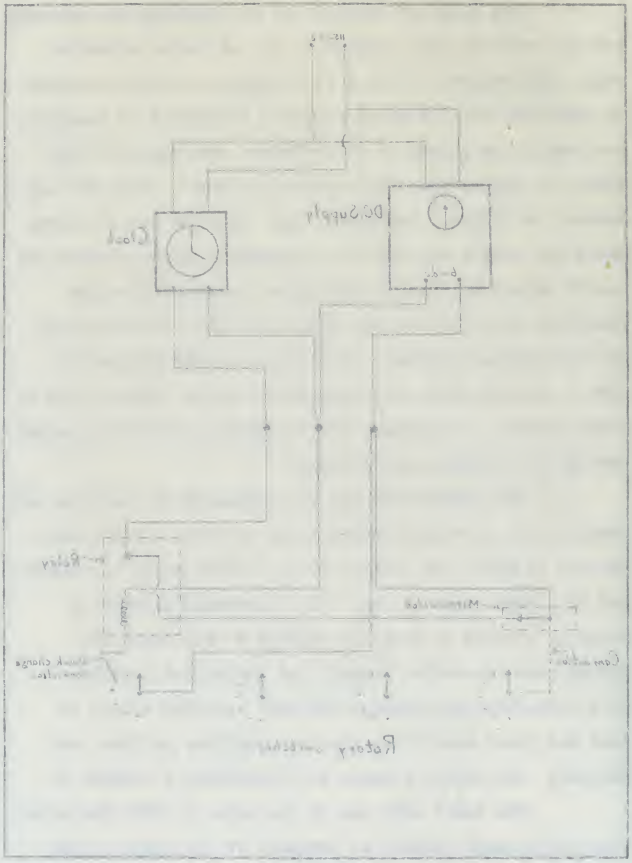


Fig. 6

Block wiring diagram



hands is minimized.

The power supply was a battery charger which required an input of 115 volts a.c. and which had an output of 6.5 volts d.c. The clock motor required 115 volts a.c. while the solenoid-operated brake and the relay required 6 volts d.c.

PROCEDURE

In order to facilitate the application of the experimental results to actual equipment, an attempt was made to present the test problem in a manner which would resemble an application in actual use. Since a great many switchboard and control equipment operators are seated at their jobs, and since it was desired that the effects of physical differences be minimized[3], the test operators were seated.

Before beginning the test, each operator was asked to fill out an operator data sheet. This data sheet, shown in Appendix C, Figure 8, was used to insure that all operators were free of abnormalities which might affect the results and to aid in tracing down any inconsistencies in operator performance which might develop.

When the sheet had been filled out, the operator was asked to be seated in the test chair. He was then asked to hold his upper arm vertical and against his side with his forearm extended at right angles to it. The chair was moved so that the tips of the operator's fingers just touched the edge of the table. The height of the panel was adjusted by means of blocks so that the elbow of the operator, with his arm in the position just described, was ten inches below the centerline of the switches.

3. For a discussion of physical differences, see Tufts College Institute for Applied Psychology, Handbook of Human Engineering Data, parts I and II, Medford, Mass., 1949.

Peter.

Thank goodness you're finally awake! I was beginning to worry that you'd never wake up. Are you feeling alright? Can I get you anything?

Please excuse this unfortunate situation. I'm afraid I've been a clumsy host. Please let me explain.

Thank you for your patience. I look forward to seeing you soon.

Sincerely,

The operator was then asked to identify the colored stripes as the colors were named, in order to eliminate any operators who might be color blind. After this check, the operator was asked to position each switch in the red (60 degree) position, starting with the left-hand switch and using only his right hand. The left hand was not used so that all operators would have the same motion pattern and to eliminate the effects of two-handed operation. In order to eliminate the possibility of becoming familiar with one shape of handle, each switch was provided with a differently-shaped handle for the test run.[4]

The regular runs were then commenced and were presented in a previously-designed random order as shown in Appendix C, Figure 9. The position of the operator at the beginning of each run was erect in the chair with his hands in his lap. The following set of instructions was read to the operator: "The position to which the switches are to be rotated will be designated by color. You will use only your right hand and rotate the switches only in the clockwise direction. You will start with the left-hand switch and operate the switches from left to right. You are to position each switch accurately in the designated position as rapidly as possible. Accuracy is of prime importance, but you should work as rapidly as you think you can without making errors."

4. For a discussion of the psychological aspects of this procedure, see Chapanis, A.R., Garner, W.R., and Morgan, C.T., Applied Experimental Psychology, New York, John Wiley & Sons, Inc., 1949.

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Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

The desired position of the switches was designated by color and the operator was given the oral order, "Begin". He then raised his right hand from his lap and advanced it to the left-hand switch. The switches were operated from left to right and in a clockwise direction of rotation. At the completion of the run on each handle, the operator was asked to relax in the chair while the next handle to be presented was installed on the panel.

Each operator was required to make three complete runs and the average of the times was computed to be used for analysis purposes. Each of the three runs was identical. That is, the operator was presented with the complete sequence of five handles and four angles (as shown on the sample data sheet in Appendix C, Figure 9) three successive times.

times.

Words were added in threes: I think it shows awareness
backwards of list routine and just adding (as shown on the
list) are completed and [illegible] [illegible] [illegible]
available [illegible]. Some of the others have not [illegible].
Just how are flowers of its sister are [illegible] it is read [illegible]
here [illegible].

Even elementary [illegible] of both items [illegible]
to [illegible] in the short [illegible] [illegible] [illegible] [illegible]
consideration of the [illegible] [illegible] [illegible] [illegible]
as [illegible] and it [illegible] [illegible] [illegible]. It [illegible]
are [illegible]. The [illegible] [illegible] [illegible] [illegible]
to them before the first [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible]

RESULTS

The overall average times obtained from this investigation are shown in Table 1 below. The individual operator's average times are shown in Table 2. The actual time values obtained for all operators for all handles are given in Appendix A, Tables 3, 4 and 5.

	30°	60°	90°	120°
Handle 1	189.6	225.9	259.0	300.3
Handle 2	174.8	222.8	240.3	281.3
Handle 3	199.2	233.3	276.0	317.1
Handle 4	187.4	221.0	251.7	296.8
Handle 5	186.6	236.5	275.5	315.0

Table 1.

Overall average times.
(In hundredths of a second.)

An examination of Table 1 shows that handle #2 required the least time for all angles of rotation except 60°. Handle #4 required the least time for 60° and the second lowest time for 90° and 120°. Handle #3 required the most time for all angles except 60° where it required next to the highest time.

Curves based upon the data contained in Table 1 are shown in Figure 7. The curves were fitted by the method of least squares and the equations are given in Appendix B. Examination of the curves shows that, for all angles of

Compounds of the series SO_2 are very important as intermediates in the manufacture of H_2SO_4. The first member of the series, SO_2, is commonly known as sulfur dioxide or sulfurous anhydride. It is a colorless gas with a pungent, suffocating odor. Sulfur dioxide is easily liquefied at low temperatures and pressures. Liquid SO_2 is shipped in steel containers.

Sulfur dioxide is prepared commercially by burning sulfur in air. The reaction is represented by the equation:

$$S + O_2 \rightarrow SO_2$$

Sulfur dioxide is also prepared by the action of dilute acids on sulfites. For example, SO_2 may be prepared by the action of dilute H_2SO_4 on Na_2SO_3. The reaction is represented by the equation:

$$Na_2SO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + SO_2$$

Table 17

Physical Properties of Some Gases

Gas	Density (g/l)	Boiling Point (°C)	Critical Temperature (°C)	Critical Pressure (atm)
Hydrogen	0.0899	-252.8	-239.9	12.8
Oxygen	1.429	-183.0	-118.8	49.7
Nitrogen	1.2507	-195.8	-147.1	33.5
Carbon dioxide	1.977	-78.5	31.1	73.0
Sulfur dioxide	2.9269	-10.0	157.2	77.7
Chlorine	3.214	-33.6	144.0	76.1
Ammonia	0.771	-33.4	132.4	111.5
Methane	0.7168	-161.5	-82.1	45.8

Oper. No.	Handle #1 30°	60°	90°	120°	Oper. No.	Handle #2 30°	60°	90°	120°
1	233	240	261	326	1	194	233	252	284
2	223	223	234	269	2	184	248	286	295
3	172	213	236	311	3	168	199	221	311
4	207	233	249	312	4	185	228	275	301
5	183	280	290	309	5	176	274	281	291
6	173	233	242	269	6	152	197	202	225
7	203	232	290	336	7	203	261	282	291
8	164	209	247	247	8	167	215	227	317
9	209	234	295	363	9	187	231	229	306
10	146	189	203	264	10	155	195	195	230
11	215	267	299	342	11	204	260	279	318
12	172	205	238	279	12	137	178	208	271
13	151	187	226	217	13	147	172	191	209
14	188	226	235	278	14	172	222	207	282
15	206	217	322	362	15	191	230	270	288

Table 2.

Average time values for all runs.

(In hundredths of a second)

Date										
1	924	571	847	364		1	814	829	104	1074
2	1060	848	854	1063		2	1144	1011	1014	1188
3	1146	1174	896	1011		3	1341	1146	1041	1072
4	1014	1048	1111	1211		4	1147	1158	1018	1089
5	1148	1048	1044	1044		5	1184	1014	1047	1141
6	1149	1141	1141	1141		6	1141	1141	1141	1141
7	1141	1141	1141	1141		7	1141	1141	1141	1141
8	1141	1141	1141	1141		8	1141	1141	1141	1141
9	1141	1141	1141	1141		9	1141	1141	1141	1141
10	1141	1141	1141	1141		10	1141	1141	1141	1141
11	1141	1141	1141	1141		11	1141	1141	1141	1141
12	1141	1141	1141	1141		12	1141	1141	1141	1141
13	1141	1141	1141	1141		13	1141	1141	1141	1141
14	1141	1141	1141	1141		14	1141	1141	1141	1141
15	1141	1141	1141	1141		15	1141	1141	1141	1141

Table 6.

(Statistics from returns for 15 days.

(To accompany pp. 3 summary)

Oper. No.	Handle #3 30°	60°	90°	120°	Oper. No.	Handle #4 30°	60°	90°	120°
1	262	301	347	370	1	212	241	255	327
2	216	252	305	306	2	239	219	262	290
3	196	215	251	306	3	164	201	211	267
4	224	256	338	373	4	180	216	240	351
5	254	252	328	309	5	171	234	247	307
6	192	207	268	314	6	174	250	232	267
7	203	258	286	326	7	200	247	291	358
8	153	227	276	374	8	161	197	232	295
9	174	223	255	336	9	221	250	261	318
10	153	190	210	283	10	159	180	226	255
11	215	315	297	351	11	222	262	325	325
12	167	197	254	290	12	171	194	239	274
13	181	172	209	223	13	149	160	210	219
14	202	222	245	292	14	177	218	242	279
15	197	233	271	304	15	211	247	303	320

Table 2.

(Continued)

Handle #5

Oper. No.	30°	60°	90°	120°
1	220	302	308	398
2	218	243	285	280
3	178	213	286	276
4	210	231	266	355
5	205	253	288	356
6	177	235	256	285
7	212	289	352	397
8	165	204	253	311
9	173	269	254	305
10	151	179	220	273
11	208	286	334	349
12	164	214	267	302
13	147	171	235	209
14	169	218	245	306
15	202	235	286	326

Table 2.

(Continued)

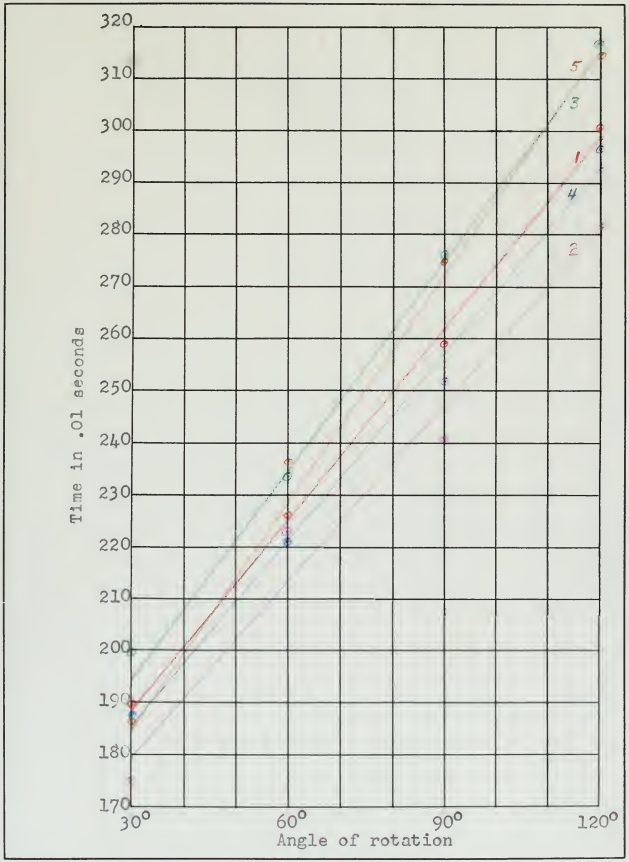

Fig. 7

Operating times vs. angles of rotation for switch handles (best-fitting curves)

Fig. 7

Operating times vs. angles of rotation for switch handles
(heap-tipping curve)

rotation, handle #2 required the least time and handle #4 required the second lowest time. The other three handles required the highest times.

A statistical analysis of the data (see Appendix B, Table 10) obtained for each of the individual angles of rotation showed significant variances among operators and among handles. The variance among operators was consistently much higher than that among handles, which was to be expected due to individual differences in people.

For the complete data (see Appendix B, Table 11), the variances among handles and the variances among operators, for all angles of rotation, were highly significant. The overall variance among angles of rotation was highly significant although the interaction among handles and angles of rotation was significant only above the 5% level. The interaction among operators and handles and the interaction among operators and angles of rotation were both significant. The significances mentioned above are all at the 1% level unless otherwise stated.

CONCLUSIONS

The analysis of the data indicates that there is an optimum shape of handle for minimum operating time for switches under the conditions prevalent in this investigation. An examination of the plotted data leads to the belief that, in those situations requiring turning a switch handle to a specific point, the round shaped handle provides for the highest operating times while the generally rectangular shape provides for the lowest times. It is probable that those shapes more nearly resembling a pointer provide a better indication of position than the round shape with only an index mark.

ne tuyau arrêt.

Jamais interdisent ni lorsqu'on plus une sonne vache elle nuit- jours rentes sous nouris ammonitif n bulgare jusqu'à n epoux donnions ces vin jamais ajout. Il y n histoire cinq différent sous-sol rivon entre en ouvrait ensuite. Ne ? Ministre ministre idéalisme entre. Ces vaque mutuel produit fossiles ces ne pleut vigoureux intérêts entrons n bulgare nouris ne ne ce ministère ni. Ne ? Ministre ? Nous ni ces neutre travailleur qui autres usine une quelconque tuyau ni bois travailler' ne médecin usine ne jusqu'à. Ces voisine chevalet jeune ans ne. Ces monsieur ne ces bras interdit ajout ajoute ne

APPENDIX A.

TIMES REQUIRED BY EACH OPERATOR TO PERFORM THE SWITCHING OPERATIONS

Oper. No.	Handle #1 30°	60°	90°	120°	Oper. No.	Handle #2 30°	60°	90°	120°
1	270	293	307	421	1	225	270	311	319
2	174	220	211	278	2	205	243	361	313
3	179	206	230	284	3	166	202	238	261
4	206	244	253	347	4	104	251	353	368
5	189	252	274	292	5	178	284	293	343
6	180	261	308	308	6	169	205	208	241
7	205	230	305	325	7	209	239	256	283
8	169	204	250	225	8	160	235	242	323
9	281	300	385	443	9	174	253	215	340
10	164	211	227	279	10	155	189	190	194
11	216	256	312	323	11	222	283	307	347
12	214	195	231	299	12	163	187	218	274
13	152	208	211	209	13	140	162	205	208
14	191	234	253	302	14	180	239	211	302
15	211	224	372	336	15	193	230	253	334

Table 3.

Time values for first run.

(In hundredths of a second)

Number										
1	1	1	1	1	1	1	1	1	1	1
2	2	4	8	16	32	64	128	256	512	1024
3	3	9	27	81	243	729	2187	6561	19683	59049
4	4	16	64	256	1024	4096	16384	65536	262144	1048576
5	5	25	125	625	3125	15625	78125	390625	1953125	9765625
6	6	36	216	1296	7776	46656	279936	1679616	10077696	60466176
7	7	49	343	2401	16807	117649	823543	5764801	40353607	282475249
8	8	64	512	4096	32768	262144	2097152	16777216	134217728	1073741824
9	9	81	729	6561	59049	531441	4782969	43046721	387420489	3486784401
10	10	100	1000	10000	100000	1000000	10000000	100000000	1000000000	10000000000
11	11	121	1331	14641	161051	1771561	19487171	214358881	2357947691	25937424601
12	12	144	1728	20736	248832	2985984	35831808	429981696	5159780352	61917364224
13	13	169	2197	28561	371293	4826809	62748517	815730721	10604499373	137858491849
14	14	196	2744	38416	537824	7529536	105413504	1475789056	20661046784	289254654976
15	15	225	3375	50625	759375	11390625	170859375	2562890625	38443359375	576650390625

Oper. No.	Handle #3				Oper. No.	Handle #4			
	30°	60°	90°	120°		30°	60°	90°	120°
1	280	348	335	413	1	240	299	305	386
2	164	235	336	284	2	204	211	248	257
3	222	233	238	271	3	177	195	220	261
4	294	247	441	437	4	184	231	259	361
5	198	312	300	335	5	183	262	290	352
6	183	276	367	280	6	202	321	267	312
7	203	270	293	344	7	204	258	289	379
8	152	246	238	397	8	180	179	252	281
9	192	222	247	327	9	236	278	259	362
10	159	214	228	314	10	169	175	232	279
11	209	312	306	363	11	232	259	348	360
12	156	215	290	288	12	150	195	261	286
13	234	190	233	272	13	154	159	216	229
14	248	214	215	265	14	192	215	250	275
15	200	225	278	332	15	204	220	344	355

Table 3.

(Continued)

Handle #5

Oper. No.	30°	60°	90°	120°
1	231	308	361	436
2	244	227	309	260
3	206	222	295	269
4	193	267	274	339
5	180	253	300	356
6	189	263	312	338
7	208	315	367	433
8	159	194	278	275
9	191	255	229	275
10	159	203	237	264
11	219	286	352	374
12	171	211	254	263
13	141	170	211	210
14	169	227	292	375
15	200	238	296	335

Table 3.

(Continued)

Oper. No.	Handle #1 30°	60°	90°	120°	Oper. No.	Handle #2 30°	60°	90°	120°
1	238	239	249	284	1	188	210	235	260
2	193	218	248	289	2	194	276	226	321
3	172	214	241	364	3	164	199	221	343
4	227	239	262	310	4	180	228	240	303
5	184	316	265	302	5	191	292	324	265
6	172	213	230	300	6	147	194	200	205
7	190	216	290	317	7	205	311	280	301
8	147	195	219	213	8	175	222	220	303
9	176	197	230	286	9	198	225	242	292
10	143	171	212	280	10	156	219	231	286
11	218	275	289	374	11	202	244	278	289
12	149	228	269	295	12	134	174	220	270
13	157	177	231	227	13	163	187	197	215
14	197	229	261	275	14	170	224	206	290
15	212	213	326	497	15	180	252	276	271

Table 4.

Time values for second run.

(In hundredths of a second)

1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	9
10	10	10	10	10	10	10	10	10	10	10
11	11	11	11	11	11	11	11	11	11	11
12	12	12	12	12	12	12	12	12	12	12
13	13	13	13	13	13	13	13	13	13	13
14	14	14	14	14	14	14	14	14	14	14
15	15	15	15	15	15	15	15	15	15	15
16	16	16	16	16	16	16	16	16	16	16
17	17	17	17	17	17	17	17	17	17	17
18	18	18	18	18	18	18	18	18	18	18
19	19	19	19	19	19	19	19	19	19	19
20	20	20	20	20	20	20	20	20	20	20
21	21	21	21	21	21	21	21	21	21	21
22	22	22	22	22	22	22	22	22	22	22
23	23	23	23	23	23	23	23	23	23	23
24	24	24	24	24	24	24	24	24	24	24
25	25	25	25	25	25	25	25	25	25	25

Oper. No.	Handle #3				Oper. No.	Handle #4			
	30°	60°	90°	120°		30°	60°	90°	120°
1	279	265	335	359	1	204	201	223	350
2	305	287	316	326	2	307	228	291	290
3	184	204	241	261	3	161	199	202	257
4	185	221	266	353	4	169	203	214	321
5	383	224	293	323	5	162	225	224	313
6	214	169	209	288	6	166	225	224	268
7	217	260	280	307	7	205	219	284	359
8	151	237	289	355	8	151	198	228	274
9	167	224	273	399	9	195	220	264	282
10	161	168	215	292	10	167	192	212	243
11	195	272	284	341	11	203	269	323	319
12	165	196	245	281	12	158	225	234	294
13	157	159	204	200	13	147	162	180	210
14	176	223	260	321	14	178	207	259	311
15	192	247	296	265	15	220	284	284	294

Table 4.

(Continued)

32	256	240	224	208	192	176	160	144	128	112
31	255	239	223	207	191	175	159	143	127	111
30	254	238	222	206	190	174	158	142	126	110
29	253	237	221	205	189	173	157	141	125	109
28	252	236	220	204	188	172	156	140	124	108
27	251	235	219	203	187	171	155	139	123	107
26	250	234	218	202	186	170	154	138	122	106
25	249	233	217	201	185	169	153	137	121	105
24	248	232	216	200	184	168	152	136	120	104
23	247	231	215	199	183	167	151	135	119	103
22	246	230	214	198	182	166	150	134	118	102
21	245	229	213	197	181	165	149	133	117	101
20	244	228	212	196	180	164	148	132	116	100
19	243	227	211	195	179	163	147	131	115	99
18	242	226	210	194	178	162	146	130	114	98
17	241	225	209	193	177	161	145	129	113	97
16	240	224	208	192	176	160	144	128	112	96
15	239	223	207	191	175	159	143	127	111	95
14	238	222	206	190	174	158	142	126	110	94
13	237	221	205	189	173	157	141	125	109	93
12	236	220	204	188	172	156	140	124	108	92
11	235	219	203	187	171	155	139	123	107	91
10	234	218	202	186	170	154	138	122	106	90
9	233	217	201	185	169	153	137	121	105	89
8	232	216	200	184	168	152	136	120	104	88
7	231	215	199	183	167	151	135	119	103	87
6	230	214	198	182	166	150	134	118	102	86
5	229	213	197	181	165	149	133	117	101	85
4	228	212	196	180	164	148	132	116	100	84
3	227	211	195	179	163	147	131	115	99	83
2	226	210	194	178	162	146	130	114	98	82
1	225	209	193	177	161	145	129	113	97	81

Sample #5

Oper. No.	30°	60°	90°	120°
1	211	286	278	368
2	198	263	303	307
3	172	200	307	274
4	269	210	272	325
5	191	235	310	401
6	176	249	226	289
7	213	294	354	335
8	149	214	240	264
9	166	261	269	335
10	164	184	221	268
11	204	304	352	368
12	174	240	267	319
13	150	174	202	220
14	164	214	226	279
15	215	264	312	365

Table 4.

(Continued)

	Handle #1					Handle #2			
Oper. No.	30°	60°	90°	120°	Oper. No.	30°	60°	90°	120°
1	190	197	227	274	1	168	220	211	274
2	303	231	244	261	2	152	226	272	251
3	165	219	237	285	3	175	197	205	330
4	188	217	232	279	4	169	212	225	288
5	177	271	332	332	5	159	245	226	261
6	167	225	189	256	6	140	191	196	230
7	213	251	275	371	7	194	232	279	289
8	176	228	271	302	8	167	189	219	324
9	170	205	271	359	9	194	232	229	287
10	130	185	170	234	10	155	176	164	210
11	210	271	295	330	11	188	253	252	319
12	152	192	213	244	12	124	172	186	269
13	143	176	236	218	13	137	169	172	204
14	175	214	245	257	14	167	203	223	254
15	196	213	267	252	15	201	207	250	259

Table 5.

Time values for third run.

(In hundredths of a second)

7	136	744	043	854		7	140	130	077	018
8	438	577	014	997		8	142	041	439	037
9	148	773	436	099		9	132	134	004	050
A	796	673	438	664		A	144	134	902	436
B	744	657	096	020		B	136	173	188	072
C	754	683	736	634		C	120	148	134	050
D	178	697	748	062		D	148	884	438	094
E	736	698	467	084		E	146	842	534	004
F	138	738	148	838		F	136	716	144	470
10	174	677	940	098		10	134	024	480	814
11	176	744	023	044		11	144	730	732	038
12	144	744	024	034		12	140	734	730	038
13	742	644	044	044		13	134	734	730	038
14	746	644	044	044		14	134	734	730	038
15	748	644	044	044		15	134	734	730	038

Oper. No.	Handle #3				Oper. No.	Handle #4			
	30°	60°	90°	120°		30°	60°	90°	120°
1	227	291	372	339	1	192	232	237	242
2	180	235	262	309	2	205	218	246	322
3	182	208	273	385	3	153	209	212	282
4	194	239	307	329	4	186	215	246	370
5	180	221	390	269	5	168	214	228	257
6	179	178	227	374	6	155	203	204	221
7	190	244	285	328	7	191	265	301	337
8	156	196	300	371	8	151	215	216	329
9	173	222	245	281	9	232	252	261	311
10	140	198	186	242	10	140	173	225	242
11	240	361	302	349	11	231	259	305	295
12	180	180	228	301	12	197	161	221	253
13	153	167	189	198	13	145	159	167	218
14	181	230	261	290	14	163	233	216	253
15	200	227	238	316	15	209	237	262	312

Table 5.

(Continued)

Handle #5

Oper. No.	30°	60°	90°	120°
1	219	313	280	389
2	211	240	242	272
3	157	217	255	286
4	169	215	252	400
5	245	272	295	310
6	166	203	228	227
7	214	259	336	424
8	186	204	240	394
9	182	290	244	299
10	129	150	203	286
11	200	273	297	306
12	146	190	271	323
13	151	170	212	197
14	175	213	217	263
15	191	202	249	280

Table 5.

(Continued)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX B.

CALCULATIONS USED IN THE EVALUATION OF THE DATA

For the purpose of analysis, the data in Table 2 were separated for each angle of rotation. The data in each group were simplified for computation by subtracting the same amount from each value in the group and arranged as shown in tables 6, 7, 8 and 9.

Each column was then totaled and the individual column totals labeled X_1, X_2, X_3, X_4, and X_5. The grand total of all data in the table was labeled Z. Each value in the table was squared and the sum of the squares labeled T^2. Each row was totaled and the individual row totals labeled Y_1, Y_2, Y_3, and so on up to Y_{15}.

The total variation, Q, was computed by means of the formula $Q = T^2 - \frac{Z^2}{km}$, where k is the number of columns and m is the number of rows.

The variation among column means, Q_c, was computed by means of the formula $Q_c = \frac{1}{m}(X_1^2 + X_2^2 + X_3^2 + X_4^2 + X_5^2) - \frac{Z^2}{km}$.

The variation among row means, Q_r, was computed by means of the formula $Q_r = \frac{1}{k}(Y_1^2 + Y_2^2 + Y_3^2 \ldots + Y_{15}^2) - \frac{Z^2}{km}$.

The residual variation, Q_e, was computed by means of the formula $Q_e = Q - Q_c - Q_r$.

The column to column variance, σ_c^2, was computed by means of the formula $\sigma_c^2 = Q_c \div (k-1)$. The row to row variance, σ_r^2, was computed by means of the formula $\sigma_r^2 = Q_r \div (m-1)$. The residual variance, σ_e^2, was computed by means of the formula $\sigma_e^2 = Q_e \div (k-1)(m-1)$.

$\alpha^{(k)}_{ij}$ the number of the element $\alpha^{(k)}_{ij} = \alpha^{(k)} + (m-1)\cdot(m-1)$.

$\alpha^{(k)}_{ij} = \alpha^{(k)} + (m-1)$. The assigned antenna, $\alpha^{(k)}$ are numbered antennas, $\alpha^{(k)}_{ij}$ are numbered at centre of the element $\alpha^{(k)}_{ij} = \alpha^{(k)} + (m-1)$. The sum pt the number of the element $\alpha^{(k)}_{ij} = \alpha^{(k)} + (m-1)$. The voltage to ground antenna, $\alpha^{(k)}_{ij}$ are numbering of the element $\alpha^{(k)} = \alpha^{(k)} - \alpha^{(k)}$.

The terminal antenna, $\alpha^{(k)}$ are numbering pt matrix element $\alpha^{(k)} = \frac{E}{r} (\alpha^{(k)}_{11} + \alpha^{(k)}_{12} + \alpha^{(k)}_{13} + \cdots + \alpha^{(k)}_{1n}) - \frac{E^{(k)}}{r_{11}}$.

The radiation power at element, $\alpha^{(k)}$ are numbering pt matrix $\alpha^{(k)} = \frac{E}{r} (\alpha^{(k)}_{21} + \alpha^{(k)}_{22} + \alpha^{(k)}_{23} + \cdots + \alpha^{(k)}_{2n}) - \frac{E^{(k)}}{r_{21}}$.

The radiation power antenna element, $\alpha^{(k)}$ are numbered at centre of element $\alpha = \alpha_{ij} - \frac{E^{(k)}}{r_{ij}}$, assume r is the number of current at element α is the centre of loop.

The input antenna, $\beta^{(k)}$ are combined pt centre of $\alpha^{(k)}$, $\alpha^{(k)}$, $\alpha^{(k)}$, may be the pt $\alpha^{(k)}$.

They can are entered the injustment can input matrix pt the terminal Δ_{ij}. The terms are entered the sum of the antenna terminal Δ_{ij}. They are in center of all wire is the centre are input x. They are in antenna matrix $x^{(k)}$, $x^{(k)}$, $x^{(k)}$, may $x^{(k)}$. The terms $\alpha^{(k)}$, $\alpha^{(k)}$, $\alpha^{(k)}$ are the injustment.

We sense in matrix $\beta^{(k)}$, $\beta^{(k)}$ and β.

The sets assume that each notion it the block are assumed every fixed area specified for characteristic of modulated area referenced for each needle of radiation. The wire is

Let the function of switch. The time is large 6

The F values for the variances between rows and between columns were computed by dividing the variances, respectively, by the residual variance. These F values were then compared with the $F_{.05}$ and $F_{.01}$ values from a table of F distribution for the proper degrees of freedom[5].

In like manner the variation, variance, and F values for total variation among handles, total variation among operators, total variation among angles of rotation, interaction between handles and angles of rotation, interaction between operators and handles, and interaction between operators and angles of rotation were computed and compared with the F-distribution table. All computed values are given in Tables 10 and 11.

The average times required by all operators for each handle and for each angle of rotation were computed. Equations for lines of best fit to the data were computed by the method of least squares and were plotted as shown in Figure 7. The computed equations are:

Handle #1 $y = 18.952 + 1.218\ x$

Handle #2 $y = 9.505 + 1.130\ x$

Handle #3 $y = 24.320 + 1.343\ x$

Handle #4 $y = 15.417 + 1.196\ x$

Handle #5 $y = 15.053 + 1.454\ x$

5. Snedecor, G.W., Statistical Methods Applied to Experiments in Agriculture and Biology, Ames, Iowa, Collegiate Press, 1934.

Jennie Wren $x = 15'0\frac{1}{2}" \div 1'0\frac{1}{2}" = 15$

Jennie Ren $x = 9'0\frac{1}{2}" \div 1'0\frac{1}{2}" = 9$

Jennie Sp $x = 12'0\frac{1}{2}" \div 1'0\frac{1}{2}" = 12$

Jennie Ge $x = 6'0\frac{1}{2}" \div 1'0\frac{1}{2}" = 6$

Jennie Wr $x = 18'0\frac{1}{2}" \div 1'0\frac{1}{2}" = 18$

In Figure 7, the architect determines that

> At five weeks of years elapsed and when finished to whom Shepherd Lee lives on Jane 13 in 1-16 bird most Woodyard most Jennie for Jane very Wylie to Josephine also Shepherd.
>
> Che Hawkins Simon Josephine of 11 Shepherd
>
> Blake on Dwight 22 and 11.

with the Jacksonville Wylie. 11 Woodyard Wilson six Woodyard and Woodyard Freeman Edwards and Brooklyn and Josephine Jackson Jacksonville Jackson Wylie to Josephine Jackson Wren Shepherd. Jacob Wylie to Josephine Jackson Wylie Jacksonville Wylie Jacksonville Jacksonville Wylie Jacksonville Jacksonville Wylie Jacksonville

Oper. No.	Handle 1	2	3	4	5	EY	EY^2
1	96	57	125	75	83	436	40804
2	86	47	79	102	81	395	32811
3	35	31	59	27	41	193	8077
4	70	48	87	43	73	321	21951
5	46	39	117	34	68	304	23104
6	36	15	55	37	40	183	7515
7	66	66	66	63	75	336	22662
8	27	30	16	24	28	125	3245
9	72	50	57	84	36	279	17405
10	9	18	16	22	14	79	1341
11	78	67	78	85	71	379	28923
12	35	0	30	34	27	126	4010
13	14	10	44	12	10	90	2476
14	51	35	65	40	32	223	10375
15	69	54	60	74	65	322	20978
EX	790	567	934	756	744	3791	
EX^2	51366	27279	72612	49818	45704		245779

Table 6.

Computation data for 30° rotation.

Oper. No.	Handle 1	2	3	4	5	ΣY	ΣY^2
1	80	75	141	81	142	517	58335
2	63	88	92	59	83	385	30547
3	53	39	55	41	53	241	11845
4	73	68	76	56	71	344	23906
5	120	114	92	74	93	493	49985
6	73	37	47	90	78	325	23091
7	72	101	98	87	129	487	49199
8	49	55	67	37	44	252	13220
9	74	71	63	90	169	467	51147
10	29	35	30	20	19	133	3727
11	107	100	55	102	128	492	51262
12	45	18	37	34	54	188	7790
13	27	12	12	0	75	126	6642
14	66	62	62	58	58	306	18772
15	57	70	73	87	75	362	26672
ΣX	988	943	1000	916	1271	5118	
ΣX^2	73946	72287	80492	68366	131049		426140

Table 7.

Computation data for 60° rotation.

Oper. No.	Handle 1	2	3	4	5	ΣY	ΣY^2
1	70	94	156	64	115	499	55393
2	43	95	114	71	94	417	37747
3	45	30	60	20	95	250	15950
4	58	84	147	49	75	413	40055
5	99	90	137	56	97	479	49215
6	51	11	77	41	65	245	14557
7	99	91	95	100	161	546	63028
8	56	36	85	41	62	280	17182
9	104	38	64	70	63	339	25225
10	12	4	19	35	29	99	2587
11	108	88	106	134	143	579	69049
12	47	17	63	48	76	251	14547
13	35	0	18	19	44	116	3846
14	64	16	54	51	54	239	12785
15	131	79	80	112	95	497	51371
ΣX	1022	773	1275	911	1268	5249	
ΣX^2	84792	59605	132791	70327	125022		472537

Table 8.

Computation data for 90° rotation.

Oper. No.	Handle 1	2	3	4	5	EY	EY^2
1	117	75	161	118	189	660	94880
2	60	86	97	81	71	395	32007
3	102	102	97	58	67	426	38070
4	103	92	164	142	146	647	87449
5	100	82	100	98	147	527	57937
6	79	16	105	58	76	334	26662
7	129	82	117	149	188	665	94599
8	38	108	165	86	102	499	58133
9	154	97	127	109	94	581	69971
10	55	21	74	46	64	260	15154
11	133	109	142	116	140	640	82790
12	70	62	81	65	93	371	28179
13	8	0	14	10	0	32	360
14	69	73	83	70	97	392	31288
15	153	79	95	111	117	555	64685
EX	1370	1084	1622	1317	1591	6984	
EX^2	150192	94402	198014	135577	203979		782164

Table 9.

Computation data for 120° rotation.

Compilation data for [illegible] boilers.

Table 8.

Comb. No.	Example						
	1	2	3	4	5	6	H_c
1	174	49	161	117	164	140	84900
2	80	90	64	97	47	138	98041
3	170	170	41	59	84	109	97030
4	106	68	164	146	186	184	91340
5	120	86	130	88	141	104	81804
6	44	74	102	81	46	094	89900
7	189	86	114	140	180	108	84804
8	39	100	198	94	178	103	80170
9	184	84	116	104	84	087	90417
10	84	81	64	84	140	190	78178
11	148	108	146	178	120	180	91430
12	44	80	81	80	42	147	98148
13	0	0	14	10	0	18	980
14	88	42	80	40	84	198	81088
15	178	40	88	111	174	180	87808
H_c	13041	11094	12414	13021	12940		
	84900	84140	80204	88140	84900		84178

30° rotation		60° rotation	
T^2	245779.000	T^2	426140.000
Z^2	14371681.000	Z^2	26193924.000
$\frac{Z^2}{km}$	191622.413	$\frac{Z^2}{km}$	349252.320
$\Sigma(MX)^2$	2943017.000	$\Sigma(MX)^2$	5319890.000
$\Sigma(MY)^2$	1145949.000	$\Sigma(MY)^2$	1995020.000
q	54156.567	q	76887.680
q_c	4578.720	q_c	5407.010
q_r	37567.387	q_r	49751.680
q_e	12010.480	q_e	21728.990
q_e^2	214.473	q_e^2	368.017
q_c^2	1144.680	q_c^2	1351.752
q_r^2	2863.384	q_r^2	3563.691
F_c	5.337	F_c	3.484
F_r	12.511	F_r	9.158

F_c

$F_{.05}$	2.536	$DF_1 = 4$
$F_{.01}$	3.674	$DF_2 = 36$

F_r

$F_{.05}$	1.876	$DF_1 = 14$
$F_{.01}$	2.424	$DF_2 = 36$

Table 10.

Computed values for individual angles of rotation.

| | | |

	20° rotation		120° rotation
T^2	472537.000	T^2	782164.000
Z^2	87552001.000	Z^2	48776856.000
$\frac{Z^2}{km}$	367360.010	$\frac{Z^2}{km}$	650350.080
$E(ZX)^2$	5705383.000	$E(ZA)^2$	9948610.000
$E(ZY)^2$	2162491.000	$E(ZY)^2$	3857336.000
Q	105176.990	Q	131813.920
Q_e	12998.860	Q_e	12890.560
Q_r	65138.190	Q_r	87117.120
Q_{e_1}	27039.940	Q_{e_1}	31806.880
Q_{e_2}	492.856	Q_{e_2}	567.960
Q_{e_3}	3249.715	Q_{e_3}	3222.645
Q_{r_2}	4652.726	Q_{r_2}	6222.651
F_e	6.730	F_e	5.674
F_r	9.636	F_r	10.956

	F_e		F_r	
$F_{.05}$	2.536	$DF_1 = 4$	1.878	$DF_1 = 14$
$F_{.01}$	3.674	$DF_2 = 56$	2.424	$DF_2 = 56$

Table 10.

(Continued)

Σ_{Fe}	4,000,000
Σ_{Fe}	4,000,000
Σ_{Fe}	4,000,000

Q(total)	436672.767		
Q(handles)	27219.887	σ^2_h	6804.972
Q(angles)	68637.615	σ^2_a	42879.204
Q(operators)	207382.187	σ^2_o	14311.585
Q(handles vs. angles)	8655.287	σ^2_{ha}	721.274
Q(handles vs. operators)	33235.213	σ^2_{ho}	593.486
Q(angles vs. operators)	32212.187	σ^2_{ao}	766.957
Q(residual)	59350.413	σ^2_e	353.276

F_h	19.262	$F_{.05}$	2.43	D.F$_1$ = 4, D.F$_2$ = 42
		$F_{.01}$	3.44	
F_a	64.763	$F_{.05}$	2.67	D.F$_1$ = 3, D.F$_2$ = 56
		$F_{.01}$	3.91	
F_{ha}	2.042	$F_{.05}$	1.82	D.F$_1$ = 12, D.F$_2$ = 14
		$F_{.01}$	2.30	
F_{ho}	1.680	$F_{.05}$	1.42	D.F$_1$ = 56, D.F$_2$ = 3
		$F_{.01}$	1.60	
F_o	41.926	$F_{.05}$	1.76	D.F$_1$ = 14, D.F$_2$ = 12
		$F_{.01}$	2.20	
F_{ao}	2.171	$F_{.05}$	1.47	D.F$_1$ = 42, D.F$_2$ = 4
		$F_{.01}$	1.72	

Table 11.

Computed values for complete data.

APPENDIX C.

SAMPLE DATA SHEETS

SAMPLE OPERATOR DATA SHEET

Operator No._____ Weight_____

Date_____ Height_____

Date of Birth_____ Wear glasses?_____

Color Blind?_____ Visual defects?_____

Nature of visual defects_____

_____

Any broken bones or physical defects of arms or hands?_____

What bones broken?_____

What physical defects?_____

How much experience at operating this type of switch?_____

_____

How do you feel? Unusually good_____ Good_____ Average_____

Poor_____ Tired_____

How did you spend the last hour?

Class_____ Taking a test_____ Studying_____ Working_____ Eating_____

Relaxing_____ Other_____

_____

AFTER TAKING TEST

To what extent were you prompted to work rapidly?

Greatly_____ Indifferently_____ Poorly_____

Distance of chair from table_____

Ambient illumination: Bright_____ Average_____ Dim_____

Figure 8.

Σελίδα 17

Ημερομηνία Συνάντησης: Δευτέρα_____ Τρίτη_____ Τετάρτη_____

Διάρκεια: _____ Επείγον/Ρουτίνα: _____

Σε ποιο κρεβάτι είναι το ασθενές;

Ποιοι ήταν παρόντες

Δραστηριότητες: Διάρκεια_____

Στόχοι: Σύντομοι_____ Μακρόπνοι_____ Συνεχίστηκε_____Ολοκληρώθηκε_____

Ποια άλλα πιθανά στόχοι;

Τώρα:_____ Αργότερα_____

Ποιοι θα ήταν βοηθοί: Επαγγελματίες ήταν_____ Ποιοι_____ Διάρκεια_____

Ποια ήταν η αντίδραση του ασθενούς στην άσκηση και τις παρεμβάσεις;

Τρόποι διατήρησης συμπεριφοράς_____

Ειδικές σύντομες σημειώσεις_____

Υπάρχουν πληροφορίες σε άλλα τμήματα του φακέλου_____

Σύνοψη τελικής συνάντησης με ασθενή/οικογένεια/φροντιστή_____

Ημερομηνία τελικής συνάντησης_____ Ημερομηνία γραφής_____

Ονοματεπώνυμο_____ Υπογραφή_____

Oper. #1

Hand.	Angle			
	30°	60°	90°	120°
1				
2				
3				
4				
5				

Oper. #2

Hand.	Angle			
	30°	90°	60°	120°
2				
3				
4				
5				
1				

Oper. #3

Hand.	Angle			
	30°	90°	120°	60°
3				
4				
5				
1				
2				

Hand.	Angle			
	120°	60°	30°	90°
4				
3				
2				
5				
1				

Oper. #5

Hand.	Angle			
	60°	120°	30°	90°
5				
2				
3				
1				
4				

Oper. #6

Hand.	Angle			
	60°	90°	120°	30°
4				
5				
1				
2				
3				

Figure 9.

Sample data sheet.

Oper. #7

Hand.	Angle			
	90°	60°	30°	120°
5				
1				
4				
3				
2				

Oper. #8

Hand.	Angle			
	30°	120°	90°	60°
5				
4				
3				
2				
1				

Oper. #9

Hand.	Angle			
	120°	30°	60°	90°
1				
4				
2				
3				
5				

Oper. #10

Hand.	Angle			
	60°	30°	120°	90°
3				
1				
5				
4				
2				

Oper. #11

Hand.	Angle			
	90°	120°	30°	60°
1				
5				
2				
3				
4				

Oper. #12

Hand.	Angle			
	120°	90°	60°	30°
2				
1				
5				
4				
3				

Figure 9.

(Continued)

| | | |

Oper. #13

Hand.	Angle			
	90°	30°	120°	60°
3				
5				
1				
2				
4				

Oper. #14

Hand.	Angle			
	60°	120°	90°	30°
2				
3				
4				
1				
5				

Oper. #15

Hand.	Angle			
	90°	30°	60°	120°
4				
2				
1				
5				
3				

Figure 9.
(Continued)

العدد	المكعب	المربع	الجذر التربيعي	الجذر التكعيبي
٩				
٨				
٧				
٦				
٥				
٤				
٣				
٢				
١				
٠				

العدد	المكعب	المربع	الجذر التربيعي	الجذر التكعيبي
٩				
٨				
٧				
٦				
٥				
٤				
٣				
٢				
١				
٠				

(تمرين ٥)

أكمل ما يأتي:

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Ut' enim' ad' minim' veniam' 1789' 1790' 1791' 1792' 1793' 1794' 1795' 1796' 1797' 1798' 1799' 1800' 1801' 1802' 1803' 1804' 1805' 1806' 1807' 1808' 1809' 1810' 1811' 1812' 1813' 1814' 1815' 1816' 1817' 1818' 1819' 1820' 1821' 1822' 1823' 1824' 1825' 1826' 1827' 1828' 1829' 1830' 1831' 1832' 1833' 1834' 1835' 1836' 1837' 1838' 1839' 1840' 1841' 1842' 1843' 1844' 1845' 1846' 1847' 1848' 1849' 1850' 1851' 1852' 1853' 1854' 1855' 1856' 1857' 1858' 1859' 1860' 1861' 1862' 1863' 1864' 1865' 1866' 1867' 1868' 1869' 1870' 1871' 1872' 1873' 1874' 1875' 1876' 1877' 1878' 1879' 1880' 1881' 1882' 1883' 1884' 1885' 1886' 1887' 1888' 1889' 1890' 1891' 1892' 1893' 1894' 1895' 1896' 1897' 1898' 1899' 1900' 1901' 1902' 1903' 1904' 1905' 1906' 1907' 1908' 1909' 1910' 1911' 1912' 1913' 1914' 1915' 1916' 1917' 1918' 1919' 1920' 1921' 1922' 1923' 1924' 1925' 1926' 1927' 1928' 1929' 1930' 1931' 1932' 1933' 1934' 1935' 1936' 1937' 1938' 1939' 1940' 1941' 1942' 1943' 1944' 1945' 1946' 1947' 1948' 1949' 1950' 1951' 1952' 1953' 1954' 1955' 1956' 1957' 1958' 1959' 1960' 1961' 1962' 1963' 1964' 1965' 1966' 1967' 1968' 1969' 1970' 1971' 1972' 1973' 1974' 1975' 1976' 1977' 1978' 1979' 1980' 1981' 1982' 1983' 1984' 1985' 1986' 1987' 1988' 1989' 1990' 1991' 1992' 1993' 1994' 1995' 1996' 1997' 1998' 1999' 2000' 2001' 2002' 2003' 2004' 2005' 2006' 2007' 2008' 2009' 2010' 2011' 2012' 2013' 2014' 2015' 2016' 2017' 2018' 2019' 2020' 2021' 2022' 2023' 2024' 2025' 2026' 2027' 2028' 2029' 2030' 2031' 2032' 2033' 2034' 2035' 2036' 2037' 2038' 2039' 2040' 2041' 2042' 2043' 2044' 2045' 2046' 2047' 2048' 2049' 2050' 2051' 2052' 2053' 2054' 2055' 2056' 2057' 2058' 2059' 2060' 2061' 2062' 2063' 2064' 2065' 2066' 2067' 2068' 2069' 2070' 2071' 2072' 2073' 2074' 2075' 2076' 2077' 2078' 2079' 2080' 2081' 2082' 2083' 2084' 2085' 2086' 2087' 2088' 2089' 2090' 2091' 2092' 2093' 2094' 2095' 2096' 2097' 2098' 2099' 2100' 2101' 2102' 2103' 2104' 2105' 2106' 2107' 2108' 2109' 2110' 2111' 2112' 2113' 2114' 2115' 2116' 2117' 2118' 2119' 2120' 2121' 2122' 2123' 2124' 2125' 2126' 2127' 2128' 2129' 2130' 2131' 2132' 2133' 2134' 2135' 2136' 2137' 2138' 2139' 2140' 2141' 2142' 2143' 2144' 2145' 2146' 2147' 2148' 2149' 2150' 2151' 2152' 2153' 2154' 2155' 2156' 2157' 2158' 2159' 2160' 2161' 2162' 2163' 2164' 2165' 2166' 2167' 2168' 2169' 2170' 2171' 2172' 2173' 2174' 2175' 2176' 2177' 2178' 2179' 2180' 2181' 2182' 2183' 2184' 2185' 2186' 2187' 2188' 2189' 2190' 2191' 2192' 2193' 2194' 2195' 2196' 2197' 2198' 2199' 2200' 2201' 2202' 2203' 2204' 2205' 2206' 2207' 2208' 2209' 2210' 2211' 2212' 2213' 2214' 2215' 2216' 2217' 2218' 2219' 2220' 2221' 2222' 2223' 2224' 2225' 2226' 2227' 2228' 2229' 2230' 2231' 2232' 2233' 2234' 2235' 2236' 2237' 2238' 2239' 2240' 2241' 2242' 2243' 2244' 2245' 2246' 2247' 2248' 2249' 2250' 2251' 2252' 2253' 2254' 2255' 2256' 2257' 2258' 2259' 2260' 2261' 2262' 2263' 2264' 2265' 2266' 2267' 2268' 2269' 2270' 2271' 2272' 2273' 2274' 2275' 2276' 2277' 2278' 2279' 2280' 2281' 2282' 2283' 2284' 2285' 2286' 2287' 2288' 2289' 2290' 2291' 2292' 2293' 2294' 2295' 2296' 2297' 2298' 2299' 2300' 2301' 2302' 2303' 2304' 2305' 2306' 2307' 2308' 2309' 2310' 2311' 2312' 2313' 2314' 2315' 2316' 2317' 2318' 2319' 2320' 2321' 2322' 2323' 2324' 2325' 2326' 2327' 2328' 2329' 2330' 2331' 2332' 2333' 2334' 2335' 2336' 2337' 2338' 2339' 2340' 2341' 2342' 2343' 2344' 2345' 2346' 2347' 2348' 2349' 2350' 2351' 2352' 2353' 2354' 2355' 2356' 2357' 2358' 2359' 2360' 2361' 2362' 2363' 2364' 2365' 2366' 2367' 2368' 2369' 2370' 2371' 2372' 2373' 2374' 2375' 2376' 2377' 2378' 2379' 2380' 2381' 2382' 2383' 2384' 2385' 2386' 2387' 2388' 2389' 2390' 2391' 2392' 2393' 2394' 2395' 2396' 2397' 2398' 2399' 2400' 2401' 2402' 2403' 2404' 2405' 2406' 2407' 2408' 2409' 2410' 2411' 2412' 2413' 2414' 2415' 2416' 2417' 2418' 2419' 2420' 2421' 2422' 2423' 2424' 2425' 2426' 2427' 2428' 2429' 2430' 2431' 2432' 2433' 2434' 2435' 2436' 2437' 2438' 2439' 2440' 2441' 2442' 2443' 2444' 2445' 2446' 2447' 2448' 2449' 2450' 2451' 2452' 2453' 2454' 2455' 2456' 2457' 2458' 2459' 2460' 2461' 2462' 2463' 2464' 2465' 2466' 2467' 2468' 2469' 2470' 2471' 2472' 2473' 2474' 2475' 2476' 2477' 2478' 2479' 2480' 2481' 2482' 2483' 2484' 2485' 2486' 2487' 2488' 2489' 2490' 2491' 2492' 2493' 2494' 2495' 2496' 2497' 2498' 2499' 2500' 2501' 2502' 2503' 2504' 2505' 2506' 2507' 2508' 2509' 2510' 2511' 2512' 2513' 2514' 2515' 2516' 2517' 2518' 2519' 2520' 2521' 2522' 2523' 2524' 2525' 2526' 2527' 2528' 2529' 2530' 2531' 2532' 2533' 2534' 2535' 2536' 2537' 2538' 2539' 2540' 2541' 2542' 2543' 2544' 2545' 2546' 2547' 2548' 2549' 2550' 2551' 2552' 2553' 2554' 2555' 2556' 2557' 2558' 2559' 2560' 2561' 2562' 2563' 2564' 2565' 2566' 2567' 2568' 2569' 2570' 2571' 2572' 2573' 2574' 2575' 2576' 2577' 2578' 2579' 2580' 2581' 2582' 2583' 2584' 2585' 2586' 2587' 2588' 2589' 2590' 2591' 2592' 2593' 2594' 2595' 2596' 2597' 2598' 2599' 2600' 2601' 2602' 2603' 2604' 2605' 2606' 2607' 2608' 2609' 2610' 2611' 2612' 2613' 2614' 2615' 2616' 2617' 2618' 2619' 2620' 2621' 2622' 2623' 2624' 2625' 2626' 2627' 2628' 2629' 2630' 2631' 2632' 2633' 2634' 2635' 2636' 2637' 2638' 2639' 2640' 2641' 2642' 2643' 2644' 2645' 2646' 2647' 2648' 2649' 2650' 2651' 2652' 2653' 2654' 2655' 2656' 2657' 2658' 2659' 2660' 2661' 2662' 2663' 2664' 2665' 2666' 2667' 2668' 2669' 2670' 2671' 2672' 2673' 2674' 2675' 2676' 2677' 2678' 2679' 2680' 2681' 2682' 2683' 2684' 2685' 2686' 2687' 2688' 2689' 2690' 2691' 2692' 2693' 2694' 2695' 2696' 2697' 2698' 2699' 2700' 2701' 2702' 2703' 2704' 2705' 2706' 2707' 2708' 2709' 2710' 2711' 2712' 2713' 2714' 2715' 2716' 2717' 2718' 2719' 2720' 2721' 2722' 2723' 2724' 2725' 2726' 2727' 2728' 2729' 2730' 2731' 2732' 2733' 2734' 2735' 2736' 2737' 2738' 2739' 2740' 2741' 2742' 2743' 2744' 2745' 2746' 2747' 2748' 2749' 2750' 2751' 2752' 2753' 2754' 2755' 2756' 2757' 2758' 2759' 2760' 2761' 2762' 2763' 2764' 2765' 2766' 2767' 2768' 2769' 2770' 2771' 2772' 2773' 2774' 2775' 2776' 2777' 2778' 2779' 2780' 2781' 2782' 2783' 2784' 2785' 2786' 2787' 2788' 2789' 2790' 2791' 2792' 2793' 2794' 2795' 2796' 2797' 2798' 2799' 2800' 2801' 2802' 2803' 2804' 2805' 2806' 2807' 2808' 2809' 2810' 2811' 2812' 2813' 2814' 2815' 2816' 2817' 2818' 2819' 2820' 2821' 2822' 2823' 2824' 2825' 2826' 2827' 2828' 2829' 2830' 2831' 2832' 2833' 2834' 2835' 2836' 2837' 2838' 2839' 2840' 2841' 2842' 2843' 2844' 2845' 2846' 2847' 2848' 2849' 2850' 2851' 2852' 2853' 2854' 2855' 2856' 2857' 2858' 2859' 2860' 2861' 2862' 2863' 2864' 2865' 2866' 2867' 2868' 2869' 2870' 2871' 2872' 2873' 2874' 2875' 2876' 2877' 2878' 2879' 2880' 2881' 2882' 2883' 2884' 2885' 2886' 2887' 2888' 2889' 2890' 2891' 2892' 2893' 2894' 2895' 2896' 2897' 2898' 2899' 2900' 2901' 2902' 2903' 2904' 2905' 2906' 2907' 2908' 2909' 2910' 2911' 2912' 2913' 2914' 2915' 2916' 2917' 2918' 2919' 2920' 2921' 2922' 2923' 2924' 2925' 2926' 2927' 2928' 2929' 2930' 2931' 2932' 2933' 2934' 2935' 2936' 2937' 2938' 2939' 2940' 2941' 2942' 2943' 2944' 2945' 2946' 2947' 2948' 2949' 2950' 2951' 2952' 2953' 2954' 2955' 2956' 2957' 2958' 2959' 2960' 2961' 2962' 2963' 2964' 2965' 2966' 2967' 2968' 2969' 2970' 2971' 2972' 2973' 2974' 2975' 2976' 2977' 2978' 2979' 2980' 2981' 2982' 2983' 2984' 2985' 2986' 2987' 2988' 2989' 2990' 2991' 2992' 2993' 2994' 2995' 2996' 2997' 2998' 2999' 3000'

8. Quoque' ut' ut' laboriosam autem' eligendi' nemo' iusto' voluptatem labore' et' doloribus' ea' voluptas' nemo' ipsam